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faction. By holding it, teeth uppermost, with his feet and rubbing a nail or spike over the teeth rapidly, he succeeded in producing a noise which apparently delighted him. Skirrl, although pronounced feeble-minded on the basis of various studies of problem-solving ability and reactive tentencies, proved himself to be a mechanical genius.

The general conclusions which may be deduced from this limited experimental study of two monkeys and an orang utan are that the ape exhibits various forms of ideational behavior, whereas the reactive tendencies of monkeys are inferior in type and involve less adequate adaptation to factors remote in space or time. I suspect, from data now available, that both monkeys and apes experience ideas, and I believe that it will shortly be possible to offer convincing evidence of the functioning of representative processes in their behavior.

The original account of the results which have been summarized in this communication presents also a plan for a research station to be devoted to the study of the primates. It is pointed out that without scientific conscience we have permitted race after race of primitive man to disappear, unstudied by psychologist, sociologist, or anthropologist, or at best inadequately studied. The pertinent question of the comparative psychologist is "Are we also to permit the gorilla, chimpanzee, orang utan, and gibbon to disappear before we make them yield their incalculably valuable contribution to human enlightenment, welfare, and the general progress of science?"

[1] A new method of studying ideational and allied forms of behavior in man and other animals, these PROCEEDINGS, 2, 631, (1916).

[2] In the apparatus used for these observations, the boxes were placed in a straight line instead of on the arc of a circle. Consequently, the distance from the starting point increased from the center of the series toward the ends.

THE OSMOTIC PRESSURE AND LOWERING OF THE FREEZING-POINT OF MIXTURES OF SALTS WITH ONE ANOTHER AND WITH NON-ELECTROLYTES IN AQUEOUS SOLUTIONS

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In the work of this laboratory upon the abnormalities in behavior of salts in aqueous solutions with respect to their ionization, it seemed desirable to determine the effect of mixing salts with common ions. Since in this laboratory we have a potentiometer system which gives temperature readings to 0.00005°, the work was carried out by the freezing-point method.

Freezing-point determinations at various concentrations were made upon solutions of mannite, erythrite, potassium iodate, sodium iodate, magnesium sulphate, potassium sulphate, barium chloride, and cobalt chloride, and upon mixtures of potassium chloride and potassium nitrate, potassium chloride and mannite, potassium and sodium sulphates, and of potassium and sodium iodates. The method used was similar to that of Adams, and the same apparatus was used. Most of the analyses for the determination of the concentration of the solutions, were made by the use of a Haber-Rayleigh-Zeiss water-interferometer.

The results are expressed most clearly in the form of curves, which are presented in figures 1–3. These figures show the values of the freezing-point lowerings divided by the equivalent concentrations ($\Delta T/N$) on the Y-axis, and the logarithms of the concentrations in milli-equivalents per liter on the X-axis. Figure 1 gives the set of curves for potassium nitrate, potassium chloride, and their equimolal mixture. The curve for the mixture will be seen to lie about half-way between those which represent the salts separately. Figure 2 gives the results for sodium iodate, a uni-univalent salt, and for magnesium sulphate, a bi-bivalent salt. Potassium iodate, and an equimolal mixture of it with sodium iodate were also studied, but the two curves are not given as they are almost coincident with that for sodium iodate. Figure 3 gives those for potassium sulphate, barium chloride, and cobaltous

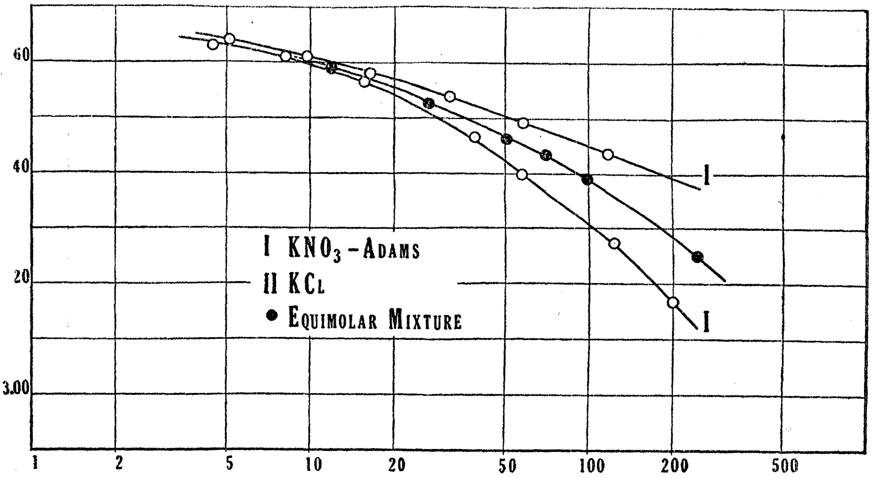

FIG. 1

chloride, three uni-bivalent salts. Lanthanum nitrate, a tri-univalent salt, was also investigated.

The general result obtained with the mixtures investigated up to the present time is that the lowering of the freezing-point of the mixture is very nearly that which would be calculated on the basis that each salt produces a lowering of the freezing-point proportional to its own concentration and to the mol-number (van't Hoff coefficient *i*) which it has

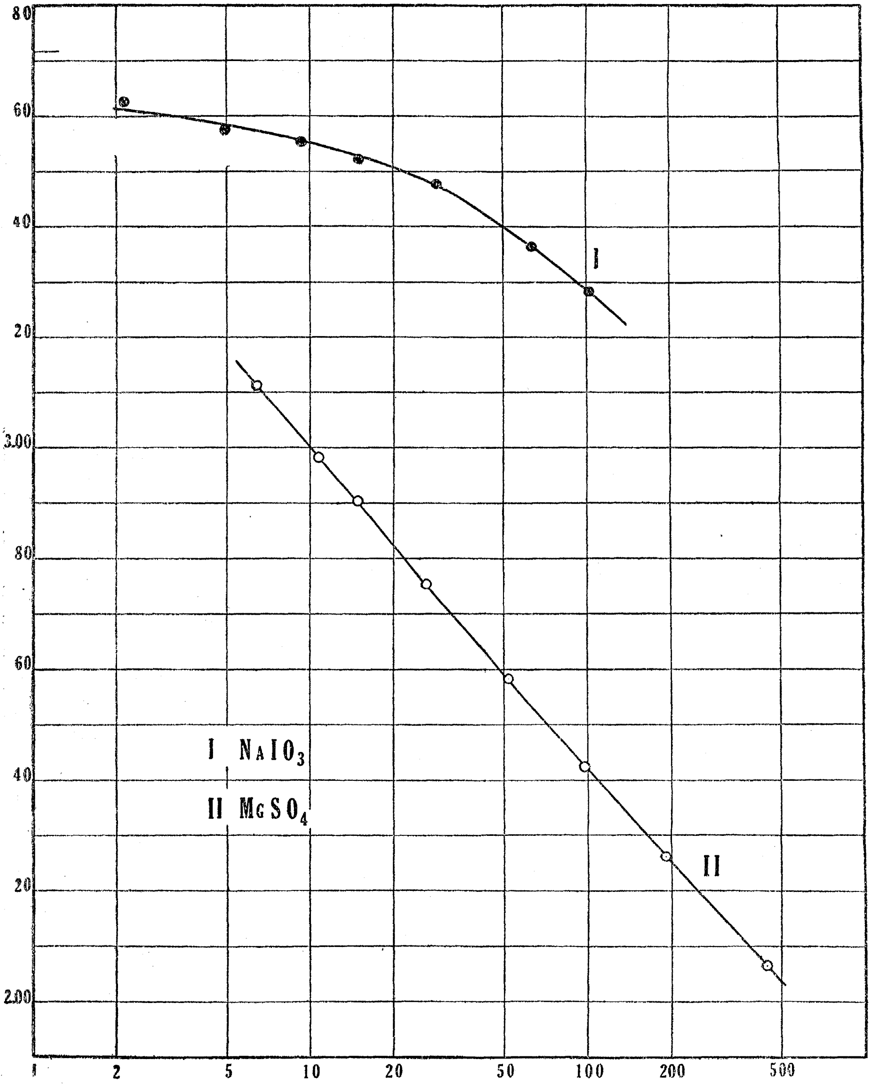

FIG. 2

when present alone in a solution of the same total salt concentration. In the 1 : 1 mixtures the freezing-point curve for the mixture lies midway between the curves for the two salts taken separately. However, it would not be surprising if later results on other salts should show somewhat different relations; for the salts thus far used have been chosen because on the whole they act normally in other respects.

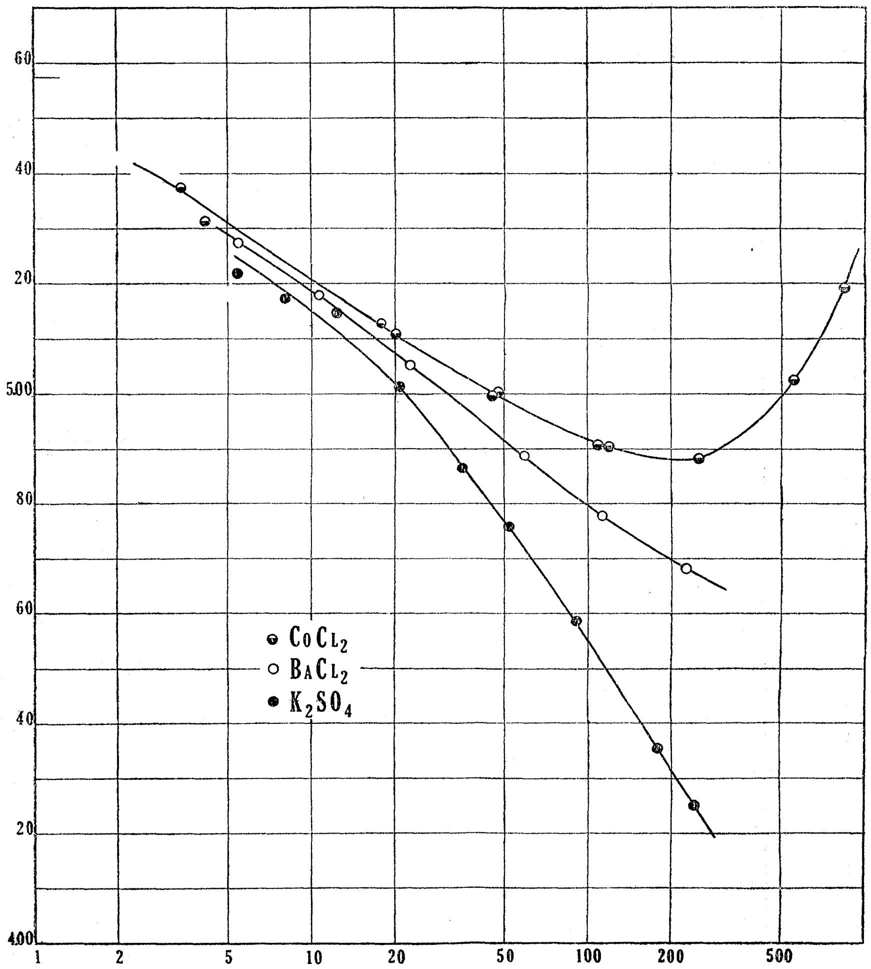

FIG. 3

The results obtained on a mixture of 1 mol of mannite and 2 mols of potassium chloride are given in the following table, which shows how closely the effect is additive. The 'deviation' given in the last column shows how much the sum of the freezing-point-lowerings caused by the separate components exceeds that observed for the mixture.

TABLE 1.

LOWERING OF THE FREEZING-POINT IN A MIXTURE OF MANNITE AND POTASSIUM CHLORIDE

CONC. MANNITE	CONC. KCl	MIXTURE	FREEZING-POINT LOWERING		DEVIATION
			Mannite	KCl alone	
0.00493	0.00987	0.04479	0.00927	0.03557	0.00005
0.01071	0.02153	0.09676	0.02012	0.07670	0.00006
0.02183	0.04367	0.19400	0.04061	0.15343	0.00004
0.04067	0.08134	0.35700	0.0757	0.2813	0.0000

So far as the writers have been able to find, this is the first work on mixtures of salts which has been carried out with an accurate temperature measuring system. One set of measurements on mixtures of a salt with a non-electrolyte has been carried out by Osaka [*Zs. physik. Chem.*, **41**, 560 (1902)], but his results show a greater deviation than that illustrated by the preceding table.

We wish to express our indebtedness to the National Academy of Sciences for a grant from the Wolcott Gibbs Fund, which was used for the purchase of the temperature measuring system, to W. P. White for the design of a special potentiometer, and to L. H. Adams and John Johnston of the Geophysical Laboratory of the Carnegie Institution for the loan of the freezing-point apparatus.

CERTAIN GENERAL PROPERTIES OF FUNCTIONS

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Let $g(x)$ be a real, one-valued, bounded, continuous or discontinuous function defined in the interval (a, b). The functional values of $g(x)$ *in the subinterval* (α, β) of (a, b) have a least upper-bound, a greatest lower-bound and a saltus, which we denote respectively by

$$u(g, \alpha\beta),\ l(g, \alpha\beta) \text{ and } s(g, \alpha\beta) = u(g, \alpha\beta) - l(g, \alpha\beta).$$

The upper-bound, the lower-bound[1] and the saltus of $g(x)$ *at the fixed point* x of (a, b) are defined respectively as the (greatest) lower-bound of $u(g, \alpha\beta)$, the (least) upper-bound of $l(g, \alpha\beta)$ and the (greatest) lower-bound of $s(g, \alpha\beta)$ for all possible subintervals (α, β) of (a, b) that contain x as interior point.[2] With the given function $g(x)$, there are thus associated three new functions of x, *the upper-bound function, the lower-bound function* and *the saltus function*, which we denote by

$$u(g, x),\ l(g, x) \text{ and } s(g, x)$$

respectively.[3]